

Aggregate Production and Testing

Construction Inspector's Training Manual

January 2006



**Washington State
Department of Transportation**

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**Washington State
Department of Transportation**
Environmental and Engineering Programs
Construction Office

Contents

Contents

Part 1	Introduction	1-1
	Objectives	1-1
	Safety	1-1
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Part 2	Production	2-1
	Quality	2-1
	Statistical Analysis	2-1
	Pits and Quarries	2-2
	Stockpiles	2-2
	Site Reclamation	2-3
<hr/>		
Part 3	Testing	3-1
	Aggregate Testing Procedure	3-1
	Rules of Testing	3-1
	WSDOT FOP for AASHTO T 2	
	Sampling Aggregate	3-2
	WSDOT FOP for AASHTO T 248	
	Reducing Samples of Aggregate to Test Size	3-3
	WSDOT for AASHTO TP-61	
	Percent of Fracture in Coarse Aggregate Terminology:	3-4
	WSDOT FOP for AASHTO T 176	
	Sand Equivalent Test	3-5
	WSDOT FOP for AASHTO T 255	
	Moisture Content of Aggregate by Drying	3-7
	WAQTC FOP for AASHTO T 27/ T 11	
	Sieve Analysis of Fine and Coarse Aggregates	3-8

Part 1

Introduction

- ***Objectives***
- ***Safety***

The Aggregate Production and Testing course helps prepare the participant to work safely in a pit or quarry site and to perform the duties of an inspector and tester for an Aggregate production operation.

The specific goals of this course are:

- Provide the inspector with the skills needed to inspect a crushing operation for compliance to the Standard Specifications.
- Provide the Aggregate tester with the initial skills to perform:
 - WSDOT FOP for AASHTO T 2
 - WSDOT FOP for AASHTO T 248
 - WAQTC FOP for AASHTO T 27/T11
 - WSDOT FOP for AASHTO T 176
 - WSDOT FOP for AASHTO T 255
 - WSDOT FOP for AASHTO TP-61

Objectives

Upon leaving this course you will be able to:

List four MSA safety factors while working in a pit or quarry.

Demonstrate six aggregate testing procedures.

Identify proper handling and stockpiling of processed materials.

Calculate the sieve analysis of a given aggregate sample.

Calculate stockpile size from production totals and compare that quantity to plan quantity for percentage of completion.

Safety

Nothing is more important than your personal safety while working in a mine. There are serious, even fatal, consequences if you aren't working in a safe manner. Use and wear your personal protective equipment, it may save your life. Once you're at the mine ask to go over the MSA site-specific checklist. (Use this as your opening statement for this section it is very powerful)

Mine safety is a matter of life and death. Throughout history miners have been killed because simple rules weren't followed and people paid the ultimate price. You are responsible for your actions. If you don't work in a safety conscious manner where heavy equipment is operating you will become a statistic in a class like this very soon.

Always check in at the “Supplier’s office” or make arrangements to meet the Supplier and have he/she direct you to the area where you’ll be sampling. Suppliers normally use two-way radio communication in the pit or quarry that helps make the miners, drillers and operators aware of your being there. Be prepared to take your sample and get to a safe location. Make sure that any equipment operator is aware of your position on the ground. Plan your exit route. Have a secondary exit strategy.

Stationary equipment can be even more dangerous. Belts carrying material don’t stop very quickly. Loose clothing is dangerous clothing. Crushers crush rock, human bone and tissue doesn’t stand a chance. Most crushers run louder than a jet engine, ear protection needs to be used properly.

Air quality can degrade throughout the day’s operation; haul routes need to be periodically watered to keep the majority of dust down. If you help set up the lab in a pit or quarry observe the wind direction and determine where upwind is most of the time and put the lab in that area. Protect your ability to breathe, wear a dust mask or in more serious conditions look in to the need for an organic respirator.

Pans used for drying material are hot; don’t get a third degree burn to prove it to yourself. Use gloves rated for the temperatures expected.

You use your feet for almost every task in your day, make sure that you’re wearing the proper ANSI safety rated boots.

Any heavy equipment, like front-end loaders, always has the right-of-way in the pit or quarry. If there’s a question of whether or not to yield, then yield.

Black River Crusher
Kent Division

Federal Mine ID No. 45-01582

NOTICE

HAZARD AWARENESS

YOU ARE ENTERING A FEDERALLY REGULATED SAND AND GRAVEL MINE. PERSONS DELIVERING GOODS, PERFORMING SERVICES, COLLECTING MATERIAL, OR VISITING AND INSPECTING THIS PROPERTY, AND WHO ARE NOT REGULAR EMPLOYEES, MAY ENCOUNTER CERTAIN HAZARDS DURING THAT TIME. VISITORS TO THIS PROPERTY ARE SUBJECT TO THE REQUIREMENTS OF EITHER THE FEDERAL MINE SAFETY AND HEALTH ACT OF 1977 OR THE OCCUPATIONAL SAFETY AND HEALTH ACT OF 1971, AS WELL AS ANY COMPANY SAFETY PROCEDURES. VISITORS MUST BE MADE AWARE OF SITE SPECIFIC HAZARDS AND ANY APPLICABLE SAFETY PROCEDURES OR RULES. ALL CONTRACTORS/SUBCONTRACTORS PERFORMING SERVICES ON MINE PROPERTIES ARE RESPONSIBLE FOR COMPLIANCE WITH PART 46 OF THE CODE OF FEDERAL REGULATIONS (CFR30) FOR MINERAL RESOURCES.

DURING YOUR TIME ON OUR PROPERTY, OBSERVE ALL POSTED RULES AND REGULATIONS, INCLUDING SPEED LIMITS, AND CAREFULLY FOLLOW ALL VERBAL INSTRUCTIONS GIVEN BY PLANT MANAGEMENT OR OTHER AUTHORIZED PERSONNEL. PLEASE IMMEDIATELY REPORT TO PLANT SUPERVISORY PERSONNEL ANY UNLISTED HAZARD YOU ENCOUNTER. YOUR ACCESS IS LIMITED TO DESIGNATED AREAS. FOR YOUR SAFETY YOU ARE NOT CLEARED OR TRAINED TO ENTER OTHER AREAS AT THIS FACILITY.

Remain in your vehicle at all times. If your business requires you to be out of your vehicle, you will need authorization from a Lakeside Industries representative.

When out of your vehicle you are required to wear proper personal protective equipment. Hard hats, safety glasses, safety vests and proper footwear are mandatory.

EMERGENCY PROCEDURE ON PAGE THREE.

**HAZARDS YOU
MAY ENCOUNTER**

PROCEDURES/RULES FOR AVOIDING INJURY

<input type="checkbox"/> Customer Trucks	Customers must remain in their vehicles or in a designated safe area during loading.
<input type="checkbox"/> Moving Equipment	Be alert and remain clear of moving equipment. Be sure the operator knows you are there. Be aware of any special traffic or driving hazards. Never park in front of or behind stopped equipment.
<input type="checkbox"/> Traffic Pattern	Traffic pattern at this facility is Right Hand unless otherwise posted.
<input type="checkbox"/> Right of Way	Haul trucks, loaders, forklifts, water trucks always have the right of way.
<input type="checkbox"/> Railroad Crossing	All vehicles will come to a complete STOP before proceeding across any railroad tracks.
<input type="checkbox"/> Power Lines	Note position of overhead power lines. Do not operate lifting devices within 50 feet of overhead cables.
<input type="checkbox"/> Moving Machinery	Be alert and remain clear of moving machinery. Do not work around or perform work on any machine that has not been stopped and blocked to make it safe from movement. If the machine is powered by electricity, then the electrical power source should be off, locked and tagged out.
<input type="checkbox"/> Wheel Chocks	Parking procedure for unattended vehicles include shutting off the engine, placing the vehicle in park or low gear, setting the park brake and chocking the wheels if not on level ground.
<input type="checkbox"/> Seat Belts	Where provided, seat belt usage is mandatory at all times while on company property
<input type="checkbox"/> Weather	Extreme weather conditions require special precautions. Visibility may be limited, walking surfaces slippery etc. High winds can also cause dust and debris to become airborne.
<input type="checkbox"/> Noise	Hearing protection is required in posted areas and other area if appropriate.
<input type="checkbox"/> Eye Protection	The use of safety glasses, goggles or face shields may be required in certain work areas.
<input type="checkbox"/> Respirable Dust	The use of a respirator may be required in certain areas.
<input type="checkbox"/> Tripping/Falling	Exercise care when getting in and out of your vehicle, and when stepping over or around any obstacle. Use handrails on stairs and walkways. Use fall protection equipment where appropriate.

- | | |
|------------------------------------|---|
| [] Falling Objects | Wear hard hat at all times. Inspect the area above where you will be working, wear hard-toed safety shoes to protect your feet. |
| [] Fire or Explosion | Obey "No Smoking or Open Flame" where posted. A permit may be required for welding in certain areas. |
| [] Injury from Lifting | Use correct lifting procedures to avoid injury, and enlist aid in lifting heavy or awkward objects. |
| [] Blasting | ONLY INDIVIDUALS DIRECTLY INVOLVED IN THE BLASTING OPERATION WILL BE ALLOWED IN THE PIT SITE DURING BLASTING. NO RADIO TRANSMISSION WILL BE ALLOWED DURING IN THE VICINITY OF THE PIT DURING BLASTING PREPARATION OR DURING BLASTING. |
| [] Ground Control | Do not attempt to enter any area where unsafe ground conditions or high walls exist. Mobile equipment in unsafe areas must be moved or towed to a safe area prior to servicing. |
| [] Welding Fumes or Exhaust Fumes | Avoid areas where excessive welding fumes or exhaust fumes are present. Allow time for ventilation. |
| [] Welding Flash | Avoid areas where welding is in progress. Do not look at welding flash. |
| [] Tools | Plan your work. Always select and use the correct tool(s) for the work at hand. Inspect tools for serviceability before using them. |
| [] Other Hazards | _____

_____ |
| [] Designated area | _____ |
-
- [] Emergency **DIAL 911**

**In an emergency, the designated assembly area is in front of the main shop.
The assembly siren is a continuous sounding of the plant start up horn.**

The Physical Address is:
Lakeside Industries
26010 180th. Ave. SE
Kent, WA 98042

Phone Numbers:
Local: --(253) 631-3611
Corporate Office--Issaquah:
(425) 313-2600

The preceding hazard awareness/training has been discharged in accordance with our training plan. To access this property you shall fully indemnify and hold Lakeside Industries harmless from any and all liability, loss or expense (including attorney fees, expert witness fees and costs) incurred as a result of your negligence or omissions at this site.

Visitor (print): _____ Company: _____

Visitor (signature): _____ Date: _____

Manager/Trainer: _____

Part 2

Production

- ***Quality***
- ***Statistical Analysis***
- ***Pits and Quarries***
- ***Stockpiles***
- ***Site Reclamation***

Quality

The quality control of aggregate products requires inspection throughout production. Materials that do not meet specifications should be rejected before being placed into stockpile or on the roadway.

Processed aggregates will be required to meet quality specifications. Pits or quarries used for Gravel Base, Ballast, Quarry Spalls, Rip-Rap, Crushed Surfacing, Portland Cement Concrete, Hot-Mix Asphalt, Backfill for Drains and Pipe Bedding are most but not all of the processed materials which have material quality specifications.

The processing plant (crusher or wash plant) is required to have an automatic sampler near the end of the delivery belt. Observe the Supplier take the sample with the sampler. The most representative sample of what the plant is producing comes from the production belt, which is where the automatic sampler needs to be.

At start up take more samples than is required for the quantity per the Construction Manual these results will help the Supplier adjust the plant into specification. If a sample is out of specification make the supplier and your up-line supervision aware immediately. The Construction Manual goes into to great detail about Statistical and Non-Statistical acceptance.

If the plant and all the surrounding activities are running at a constant speed or tempo and then as soon as a sample is taken everything ratchets up a notch or two, immediately take another sample. If you do run the second sample and it passes you're just confirming a suspicion

Statistical Analysis

The department has used non-statistical acceptance procedures for decades. Issues have arisen from the manner in which we've accepted aggregate materials. Materials that are "in tolerance but out of specification" create the most confusion. Interpreting "what to do" prompted the tester to review of chapter nine, then chapter three and finally chapter five of the Construction Manual where you'd find the process to accept or reject the material.

The one question that always came from this voyage through the Construction Manual was, "there's got to be a better way?"

The "better way" came to be in 1999 when the South Central region implemented the first statistical aggregate specification for Bituminous Surface Treatment aggregates. In short, it goes like this:

- The crushing Contractor could produce crushed materials at a composite pay factor (CPF) of 1.0 from the beginning of production.
- As long as their composite pay factor (CPF) didn't drop below a 0.75 acceptance would continue.
- How did we get a composite pay factor?

- o Double the size of the first acceptance sample for example with Crushed Surfacing Base Course (CSBC) instead of 70 lbs. the tester would get 140 lbs.
- o Using WSDOT FOP for AASHTO T-248, split or quarter, three gradation samples from the field sample.
- o Run all three samples for sieve analysis, S.E. and Fracture.
- o Input the test results into “QA Spec.” which would statistically analyze the appropriate test results and give the tester a CPF hopefully at greater than a 1.0 but not more than 1.05.

In summary, Statistical Acceptance could be used in virtually any instance where the Record of Material quantities require 3 or more tests. If possible during plan review consider recommending the Statistical Acceptance GSP to the project designer to make the testers job more efficient.

Pits and Quarries

Prior to use the State Materials Laboratory must approve all pits and quarries. The Region Materials Engineer will manage and collect preliminary samples of all pits or quarries in the region and transmit those samples to the State Materials Lab for approval. Approvals can be for as long as five years or as short as one contract.

Overburden stripped off the top of the raw material should be stockpiled for future reclamation somewhere within the site. The stripped material should be protected from erosion during that time and at a location that doesn't interfere operation of the source during crushing and stockpiling.

Records of material removal need to be given the Region Materials Engineer so that he/she is able estimate an ongoing inventory of what's been removed and what's left in the source for future use.

As removal continues from the excavation or blasting area watch for areas of radical material changes. These changes may indicate substandard material is making its way into the finish product. Undesirable material in usually means undesirable material out. The Contracting Agency is paying for specification material and every effort needs to be taken to assure the we get what we are paying for.

Stockpiles

Stockpiles are to be built in a specific manner, observe and document stockpile construction. Photo logs throughout construction are an excellent way to visually represent a quantity of material. Use a frame reference in the photo to display size.

Stake the pile per the approved plan. If the pile is larger than 200 yd³ it has to be built in four-foot deep layers. A single stockpile is limited to 24 feet in height. The floor of the stockpile must be smooth uniform surface free from debris.

Segregation of coarse and fine material is to be avoided at all times. Dumping successive truckloads adjacent to each other is the most common manner in which a layer is constructed. Equipment movement on a stockpile is restricted to striking-off each layer and loading the next layer of the pile. Conical surge piles aren't allowed. Haul routes need to be kept free from debris and care should be taken to see that deleterious material is not tracked on to the pile from haul equipment.

No steel tracked equipment is allowed on a WSDOT stockpile. Material cannot be pushed over the side of the pile. Bulldozers cannot be used to push material into a pile.

When material is being removed from a stockpile stay clear from the vertical face that develops as material is scooped away. These faces are unstable and will fall away.

In commercial pits and quarries you maybe asked to sample a stockpile. Ask the Supplier to use his front-end loader to scoop material from the working face to create a smaller pile for you to take a sample from. Ask the loader operator to pile three successive scoops on top of each other. Then have the operator drag the leading edge of the bucket back, using the leading edge like a strike-off blade, through the pile from one side to the other.

You should dig down one foot in at least three locations on the struck-off portion of the pile. This will give you the minimum number of segments for your field sample.

Site Reclamation

Contracting Agency sites that don't have 30 foot walls, on steeper than a one to one slope and aren't larger 3 acres are not required to have ultimate reclamation plans. They are required to erosion control in place. All others pits or quarries will follow the approved reclamation plan in the contract.

Part 3

Testing

- ***Record of Materials***
 - ***Aggregate Testing Procedure***
 - ***Rules of Testing***
 - ***WSDOT FOP for AASHTO T 2***
Sampling Aggregate
 - ***WSDOT FOP for AASHTO T 248***
Reducing Samples of Aggregate to Test Size
 - ***WSDOT for AASHTO TP 61***
Percent of Fracture in Coarse Aggregate
 - ***WSDOT FOP for AASHTO T 176***
Sand Equivalent Test
 - ***WSDOT FOP for AASHTO T 255***
Moisture Content of Aggregate by Drying
 - ***WAQTC FOP for AASHTO T 27/T 11***
Sieve Analysis of Fine and Coarse Aggregates
-

Aggregate Testing Procedure**WSDOT FOP for AASHTO T 2**

Standard Practice for Sampling Aggregates

WSDOT FOP T 248

Reducing Samples of Aggregate to Test Size

WSDOT for AASHTO TP 61

Determining the Percentage of Fracture in Coarse Aggregate

WSDOT FOP for AASHTO T 176

Plastic Fines in Graded Aggregates and Soil by use of the Sand Equivalent Test

WSDOT FOP for AASHTO T 255

Total Evaporable Moisture Content of Aggregate by Drying

WAQTC FOP for AASHTO T27/T 11

Sieve Analysis of Fine and Coarse Aggregates

Rules of Testing

The First Rule is: The tester will have the current test procedures on hand, and will carefully review the procedures for changes before performing that first test. All too often, over the course of the past year, changes are introduced into the test procedure that can affect the testing results.

The Second Rule is: Make certain the first rule really applies to your project. Changes to testing procedures aren't always retroactive to current contracts. Sometimes specification changes are required to accompany the changes in test procedure, but the specification change may not apply to current contracts.

WSDOT FOP for AASHTO T 2

Sampling Aggregate

Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the nature and condition of the materials that they represent. The aggregate's nominal maximum size and the table from WSDOT FOP for AASHTO T 2 are used to determine the size of the sample.

Samples from bins or belt discharge will be taken by means of a mechanical sampler. If a mechanical sampler isn't used, the tester will witness the sampling process as an employee of the material supplier does the sampling. There is too much risk of injury, for the tester to be taking the sample from the discharge stream.

Sampling from a conveyor belt requires the belt to be stopped. When taking the sample from the belt, insert a template on each side of the sample to be collected and remove all of the material from between the templates. Use a brush and dustpan to collect all the fines.

Sampling coarse aggregate or mixed coarse and fine aggregate from stockpiles or trucks is best avoided if possible. But often these are the only two options available to the tester, particularly when the material is being provided by a commercial source. To get a representative sample it will be necessary to carefully follow the procedures outlined in WSDOT FOP for AASHTO T 2.

Samples taken from within the project limits for embankment construction and /or backfill material do not require sampling by a Qualified Tester. **Materials that require gradation testing such as crushed surfacing and gravel borrow; sampling by a qualified tester is required.**

WSDOT FOP for AASHTO T 248

Reducing Samples of Aggregate to Test Size

This method covers the reduction of large samples of aggregate to the appropriate size for testing. There are two methods used for reducing the sample to testing size, Mechanical Splitter or Quartering.



Method A – Mechanical Splitter



Method B - Quartering

The table below is an outline of when it is appropriate to use the Mechanical Splitter or Quartering methods.

	Drier Than SSD	Wetter Than SSD
Fine Aggregate (FA)	Mechanical	Quartering
Coarse Aggregate (CA)	Either	Either
Mixture FA/CA	Either	Either

WSDOT for AASHTO TP 61

Percent of Fracture in Coarse Aggregate

Fractured material often exhibits better interlocking particles than smooth material. This improved interlocking results in stronger material from the standpoint of supporting a load in a road's base.

Method 2 – Combined Sieve Fracture Determination, is used by the WSDOT for determining the fracture of aggregate. The tester will count the fracture on each specified sieve, No. 4 or larger, which retains more than 5% of the total mass.

Terminology:

Fractured Face – An angular, rough or broken surface of an aggregate particle created by crushing or by other means. A face is considered a “Fractured Face” whenever one-half or more of the projected area, when viewed normal to the face, is fractured with sharp and well defined edges. This excludes small nicks.



Fractured



Un-fractured

Fractured Particle – A particle of aggregate having at least the minimum number of fractured faces specified.

WSDOT FOP for AASHTO T 176 Sand Equivalent Test

This test is intended to serve as a rapid field test to show the relative proportions of fine dust or claylike material in soils or graded aggregates.

In untreated aggregate for surfacing and backfill, fines can trap moisture that may freeze.

In concrete aggregates, fines can prevent bonding between aggregate and pastes.

In bituminous mixes, fines can prevent bonding between aggregate and binder.

Because of recent changes to this test procedure, it is very important for the tester to know which contract specifications are applicable. Older contracts may require the sample to be dampened with water and tested in a moist state. Current contracts' specifications will require the sample to be dried to a constant mass and cooled to room temperature before testing. The tester needs to know which method is specified by the contract before testing.

A key component to conducting accurate SE tests is the preparation and storage of the working calcium chloride solution. The working solution is prepared by mixing 85 ml of stock calcium chloride into 1 gallon of distilled or de-mineralized water. After making the working solution, write the date on the bottle, as the working solution can only be stored for 30 days. Also don't use any solution if you suspect it may have been frozen.



Mechanical Shaker

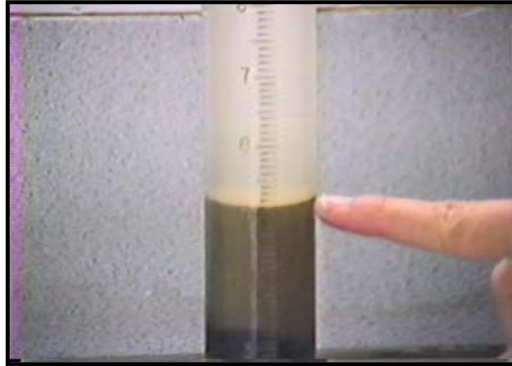


Manual Shaker

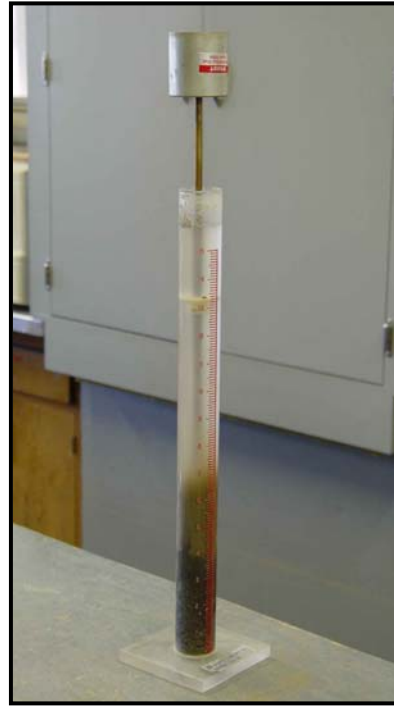
There are two approved methods for agitating the sample: the mechanical method, where a mechanical shaker shakes the sample, and the manual shaker, which is operated by hand. A tester must be qualified for the method they will be using in the field. If the tester is qualified using only the mechanical shaker, then the tester cannot use the manual shaker in the field.

To determine the sand equivalent value, the tester will divide the sand reading by the clay reading and multiply by 100. If the sand equivalent is not a whole number, report it as the next higher whole number as the following example demonstrates:

SE = 41.25, report as 42



Clear Demarcation Line
For Clay Reading



Weighted Foot Assembly
For Sand Reading

WSDOT FOP for AASHTO T 255

Moisture Content of Aggregate by Drying

This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying, both surface moisture and moisture in the pores of the aggregate. Drying of the aggregate is accomplished by using any of a number of heat sources including: a controlled temperature oven, electric or propane hot plate, electric heat lamps or a ventilated microwave oven.



Temperature Controlled Oven and the propane hot plate are the two most common methods for drying aggregate.

When drying aggregate the tester is working around hot ovens and open flames, so it is very important to wear protective clothing.

Dry the sample thoroughly by means of the selected source of heat, exercising care to avoid loss of any particles. Very rapid heating may cause some particles to explode, resulting in loss of particles. If a source of heat other than the controlled temperature oven is used, stir the sample during drying to accelerate the operation and avoid localized overheating.

The sample is dry when further heating would cause, less than 0.1 percent additional loss in mass.

WAQTC FOP for AASHTO T 27/T 11

Sieve Analysis of Fine and Coarse Aggregates

Sieve analyses are performed on aggregates used in roadway bases and in Portland cement and asphalt cement concretes. Sieve analyses reveal the size makeup of aggregate particles – from the largest to the smallest. How an aggregate is graded has a major impact on the strength of the base or on the properties and performance of concrete.

The aggregates' nominal maximum size and table 1 of this test method are used to determine the minimum sample size for testing. **The sample size must be equal to or greater than the size listed in the table for it to be a valid test.**

Before shaking the sample through the sieves, it will be necessary to dry the sample to constant mass and record the dry mass.

If the specifications require that the amount of material finer than the No. 200 sieve be determined, then the aggregate will have to be washed and decanted over nested sieves such as a No. 10 above the No. 200. *FYI - most of the specifications require the determination of material passing the No. 200 sieve.* After the aggregate has been washed, the sample will once again have to be dried back to constant mass.

Select sieves to furnish information required by the specifications and nest the sieves in order of decreasing size from top to bottom. **Avoid overloading individual sieves.** Insert additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve above. Sometimes the additional splitting of the fine aggregate may be necessary to avoid overloading the smaller sieves. The maximum allowable mass retained on a sieve can be determined from table 2 of AASHTO T 27/T 11.



“Mary Ann” Shaker

Statistical Aggregate Specification

The general special provision for statistical acceptance of aggregate is a specification the tester may find in some contracts. This specification breaks acceptance testing of aggregates in lots and sublots, which must be tracked by the tester. A “lot” is defined as the total quantity of material for an item. All of the test results shall be evaluated collectively and shall constitute a lot. Based on plan quantities, a “lot” is divided into a minimum of three uniform sized sublots. The “sublot” size will be determined to the nearest 100 tons or 50 cubic yards. The maximum sublot size will be as defined in table 1 of special provision. Sublot sampling and testing for statistical acceptance shall be performed on a random basis at the frequency of one sample per sublot. .

Test Results The Engineer will furnish the Contractor with a copy of the results of all acceptance testing performed within three working days after sampling.

The test data will be used to determine the Composite Pay Factor (CPF). The material will be determined to be acceptable if the CPF is 1.00 or greater. If the CPF is below 1.00, but equal to or above 0.75, an item price adjustment will be calculated. Lots with a CPF of less than 0.75 will be rejected.

